Activity 4: What Is So Special About The Pathfinder Landing Site?

Purpose
To show how much students can learn about Mars and the Pathfinder mission by understanding some of the criteria used to select the Pathfinder landing site.

Overview
Students examine images showing the Pathfinder landing site at three different scales. When examining each image, they discuss what each view adds to their understanding of the landing site. The activity demonstrates how images become clues in a mystery story that stimulates students to wonder, question, and speculate. In addition, it shows how students can use the clues images offer to unlock the mysteries of distant planets.

Key Concepts
- Images are a rich source of information and a stimulus for investigation.
- Scientists are conducting robotic missions to explore Mars.
- Chaotic terrain is thought to have formed when the removal of subsurface magma, water, or ice caused a loss of support, and the ground collapsed under its own weight.
- Chaotic terrain is considered a source for the fluid(s) that created the channels.
- The large channels, chaotic terrain, eroded land forms, and smooth plain at the mouth of Ares Vallis suggest that Mars experienced tremendous floods.
- The floods deposited sediment from nearly one-quarter of the planet's surface at the mouth of Ares Vallis.
- By sampling the rocks at the mouth of Ares Vallis, scientists can see if their hypothesis about Martian floods is correct as well as learn a great deal about Martian geology.

Skill Goals
- *Analyzing* images of Mars for evidence of flowing water
- *Speculating* about processes affecting the surface of Mars
- *Identifying* some of the key Martian landforms
- *Constructing* coherent explanations that are supported by evidence
- *Writing* to synthesize and communicate understanding

Materials
Student Image Sets

Time
One to two classes

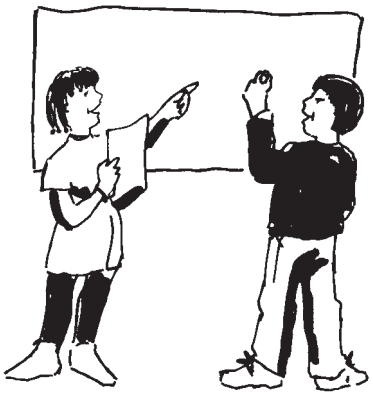
BACKGROUND

Planetary scientists rely heavily on images to investigate distant places in our solar system. These scientists study images and use the clues they offer to unlock the mysteries of our solar system. In the classroom, too, images serve as important resources for student investigations rather than simply as textbook illustrations.

Can students really use images to understand a distant planet, which geologic processes are at work, or how planetary science is done? Like scientists, students combine image analysis with other research techniques. For example, in the Mars Exploration Program students conduct experiments, make Mars-Earth comparisons, and construct models to understand individual concepts. Images are vehicles for synthesizing these concepts into coherent understandings. Once students can visualize a concept and put it in a context, they are better able to weave together seemingly separate ideas into clear, intelligible explanations. Thus, image interpretation helps students to speculate meaningfully about Mars and Martian geologic processes.

In this activity, students will try to understand scientists' rationale for selecting Ares Vallis as the landing site for Mars Pathfinder. As they review the evidence, students will see that their deductions and inferences connect with actual situations. This success will draw them deeper into the adventure of the mission as well as deeper into the adventure of planetary exploration.

You will see that images are a rich source of information and that they serve as a focal point for inquiry and investigation. Images become clues in a mystery story that stimulates students to wonder, question, and speculate. Students study the images, raise questions, draw on their experiences, and try to figure out possible interpretations. As students experience success in interpreting images, they gain confidence in their own ability to figure things out. Science becomes a set of questions to explore rather than a set of facts to be memorized.



What Is Ares Vallis?

Ares Vallis (i.e., the Ares Valley) is one of a series of channels that descend from a highland plateau to the low-lying Chryse Planitia (Chryse Plain). Ares Vallis originates in three large areas of chaotic terrain, follows a 1,800 km course and terminates in the Chryse Planitia, approximately 2.5 km below its starting elevation. The channel is 25 km wide and about 1 km deep, and many of its features lend strong support to the idea that Ares Vallis is an immense flood channel. For example, the scour marks and longitudinal grooves seen in Martian outflow channels were most likely produced by deep, high-volume, high-velocity flows.

What is so Special About the Landing Site?

Figure 4.1: The Mars Pathfinder Landing Site.
Image Set image #12.

The plain at the mouth of Ares Vallis was the landing site for Mars Pathfinder (Figure 4.1). Mission planners selected it for a number of engineering reasons such as having a relatively smooth surface to minimize landing problems, being at a low elevation to give the parachutes more time to slow the spacecraft, and being at an equatorial latitude where there was ample sunlight for the solar panels to produce electricity for the spacecraft. Another selection criterion was that Ares Vallis was likely to give scientists an unparalleled opportunity to learn about Mars' geological history. Scientists believe that the floods which created Ares Vallis eroded rocks and sediments from along its course. Ares Vallis traverses a range of rock types dating from different periods in the planet's history. The estimated scale of the floods – the largest known in the solar system - would easily carry an enormous variety of rocks and sediments down to the mouth of Ares Vallis. Scientists hope that, using just one lander, they can sample an immense area of Mars which contains rock types that formed at different stages in the planet's development. Pathfinder is currently providing data that scientists hope will shed light on a number of unanswered questions such as: Was there flowing water on Mars? Did Mars ever have an atmosphere or climate that could maintain liquid water? Did lava, mud or ice form the channels instead of water? What is the composition of the rocks in the highlands?

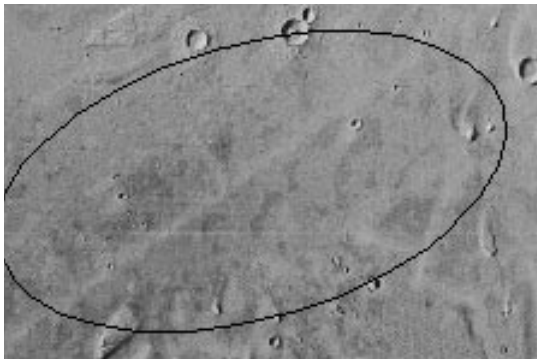
Chaotic Terrain

A common feature found within Ares Vallis' channels, along its banks, and at its head is *chaotic terrain*, a unique Martian landscape. Scientists think that the removal of ice, magma, or water from below the surface caused a loss of support, and the ground collapsed under its own weight leaving a haphazard jumble of large, irregularly shaped blocks of crust on the depression floor (Figure 4.2). Channels extend downslope from the chaotic terrain, indicating that the fluid that excavated the channels flowed from the chaos.

Figure 4.2 The Hydaspis Chaos at the head of the Tiu Vallis.
Image is 300 km across.
NASA I-1343

PROCEDURE

1. Have students examine Image Set image 9. Ask students what they notice about this region that might make it desirable as a landing site.
   Students might notice that the area appears relatively smooth, especially in contrast to the deep valleys and dense craters that predominate in other regions of Mars. This observation is important since Pathfinder needs a smooth surface on which to land because of its airbag landing technique and in order for its rover, Sojourner, to explore without confronting insurmountable obstacles.



A close-up view of the Pathfinder landing site.
Image Set image 9. Scene is 240 x 275 km

2. Have students examine Image Set image 12, a wider view of the area around the landing site. What information does this broader view add to students' understanding of image 9?
   Notice the area around the ellipse. Although there is currently no liquid water on the surface of Mars, the landforms in these images suggest that water flowed on its surface during an earlier stage of its history. The teardrop shapes around some of the craters look as if they might have formed as water flowed around them. Students might also notice a wide channel in the lower right that looks as if it might have carried water to the area of the landing site. Students might speculate that Pathfinder's landing site was once under water. See pages 61 and 62 to find out how the Pathfinder mission has yielded important information about the role of water in Mars' early history.

The area immediately surrounding the Pathfinder landing site.
Image Set image 12. Scene is 530 x 600 km.

3. To explore the question of where all the water might have come from, have students examine Image Set image 15 and trace the valley of Ares Vallis as far as they can. Have them speculate about what might have been the source(s) of water.
   As students trace the Ares Vallis valley, they may notice that its branches lead to areas of "chaotic terrain" (see the Background section for an explanation). Enormous channels lead away from these areas, suggesting that tremendous amounts of water were released when the permafrost melted.

The region south of the Pathfinder landing site. Image Set image 15. Scene is 725 x 1950 km.

4. Based on their image analysis experiences, have students piece together the story of Ares Vallis and why Pathfinder landed here.
   In this step, students mirror the work of planetary scientists by using images from robotic space probes to stimulate speculation and weave various ideas into their own hypotheses. Today, scientists believe that tremendous volumes of water erupted from chaotic terrain, cut massive channels, and spilled out onto low-lying plains. The water flowed over many different types of terrain before it reached the areas selected as the landing site. This water carried sediments from a million-square-kilometer area of the Martian surface. Consequently, the mouth of Ares Vallis is likely to contain sediments from a wide variety of rock types upstream. By sending Pathfinder to this one place, scientists could test the rocks to see if their hypothesis about the floods was correct as well as learn a great deal about Martian geology. See pages 61 and 62 to find out how the Pathfinder mission has yielded important information about the geology and hydrology of Mars.

A panoramic view of the Pathfinder landing site.

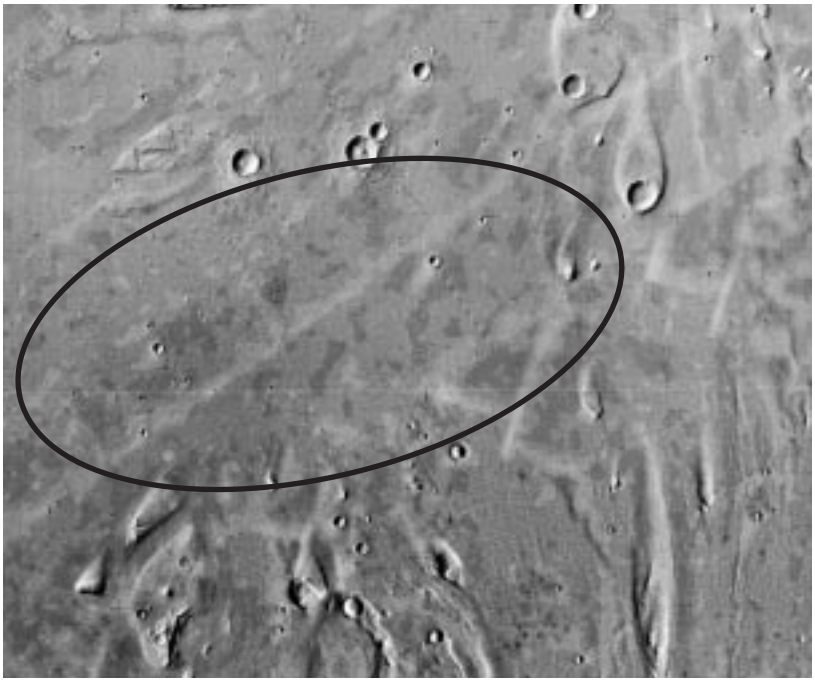
PROCEDURE cont.

5. Have students write about why Ares Vallis is a good landing site and what evidence there is to support the idea that this site may provide scientists considerable information about Mars. Students could also comment on other key elements of the mission. For example:
   - it is a real mission that is part of an on-going Mars exploration program.
   - each mission has its own specific science and engineering goals.
   - students can get information about their interests and answer their questions using the data that is easily available on the Web.
   - it is people who conceive of, design, build, launch, and run a mission.

   Consider having students write an advertising brochure proclaiming the advantages of landing at the mouth of Ares Vallis.

EXTENSION

To explore the science behind the Pathfinder mission in greater depth, use the Mars Exploration Program's module entitled, "The Great Martian Floods and the Pathfinder Landing Site." In this four-week module, students use evidence from their experiments, models, Mars-Earth comparisons, and image analysis to make a case for there once having been water on Mars. They learn how sediment, landforms, and drainage patterns provide clues about a planet's geologic history and about how Mars Pathfinder will use the sediments at the landing site to obtain information about the last four-billion years on Mars.



100 km Scale: Ellipse is 100 x 200 km.

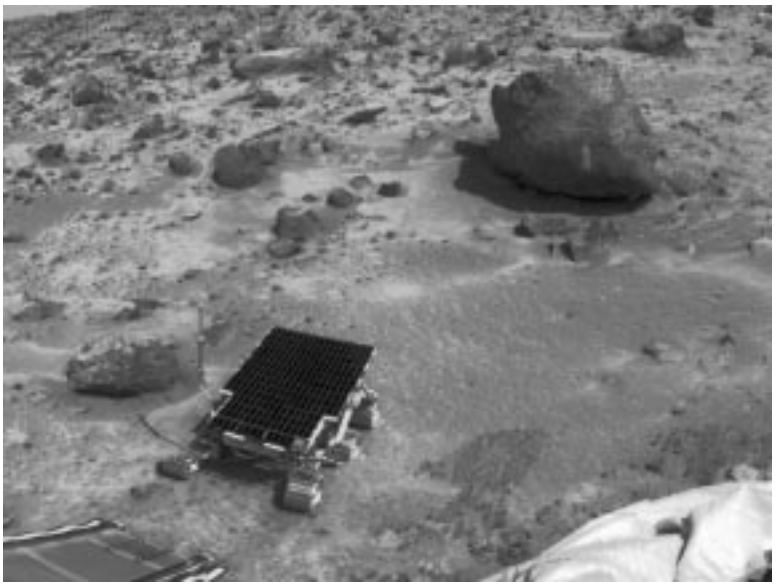
Image 9

- What is this ellipse?
- How would you describe this region?
- How might the teardrop-shaped landforms have formed?
- What might make this a desirable landing site?

200 km Scale: Ellipse is 100 x 200 km.

Image 12

- What information does this wide-area view add to your understanding of Image 9?
- Do you see anything that might make this an interesting area to explore?

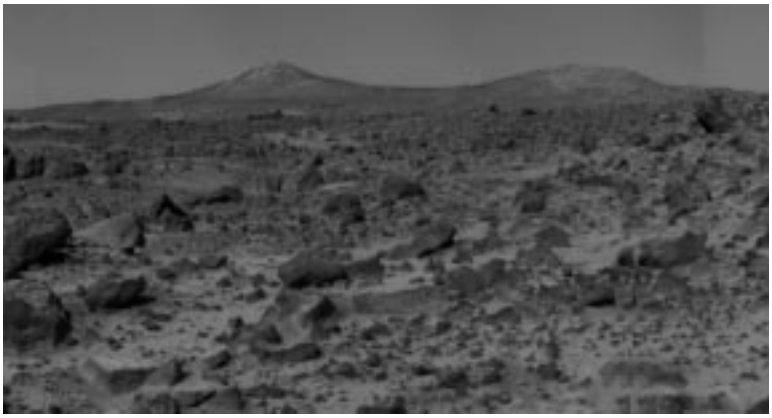


Scale: Rover is 65 cm long, 48 cm wide, and 30 cm tall.

Image 13

This image was taken on Pathfinder's third day. Here, Sojourner approaches "Barnacle Bill," the small rock on the left, and "Yogi," the large rock in the upper right-hand corner. Sojourner used its Alpha Proton X-ray Spectrometer (APXS) and cameras to determine the mineral composition of rocks and soil around the landing site. The lander's ramp and part of a deflated airbag are visible.

- How many different general rock shapes can you see?
- What causes rocks to be different shapes?
- Is the surface of Mars dusty? How can you tell?

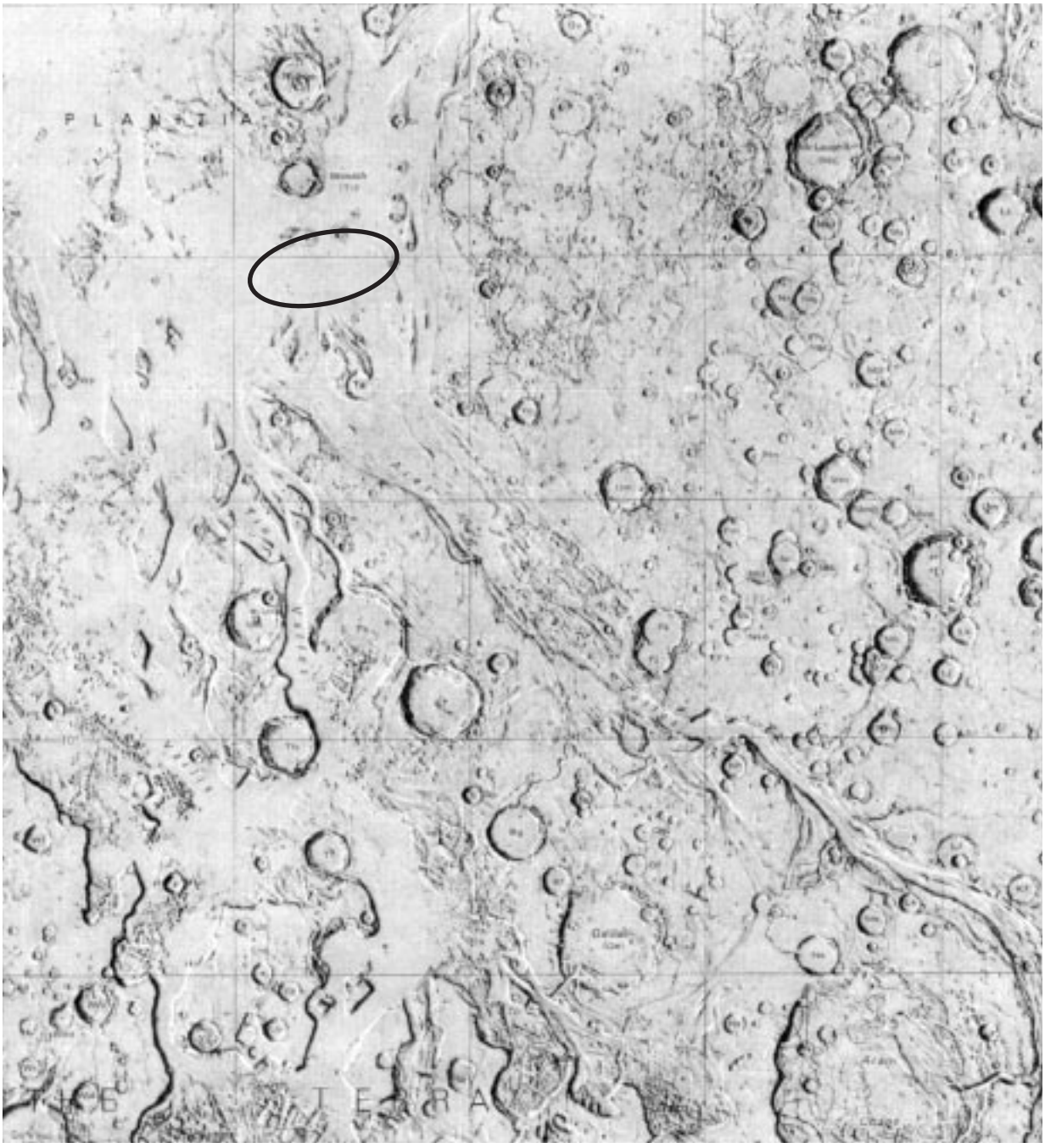


Scale: The Twin Peaks are approximately 1 km away and 50 m tall.

Image 14

This image was taken on Pathfinder's fourth day and shows "Twin Peaks," the two hills about one kilometer away from the landing site.

- Does this look like any place on Earth?
- Why did the landing site look so smooth when it is really full of boulders?
- What are some ways a plain like this can become littered with rocks?



500 km

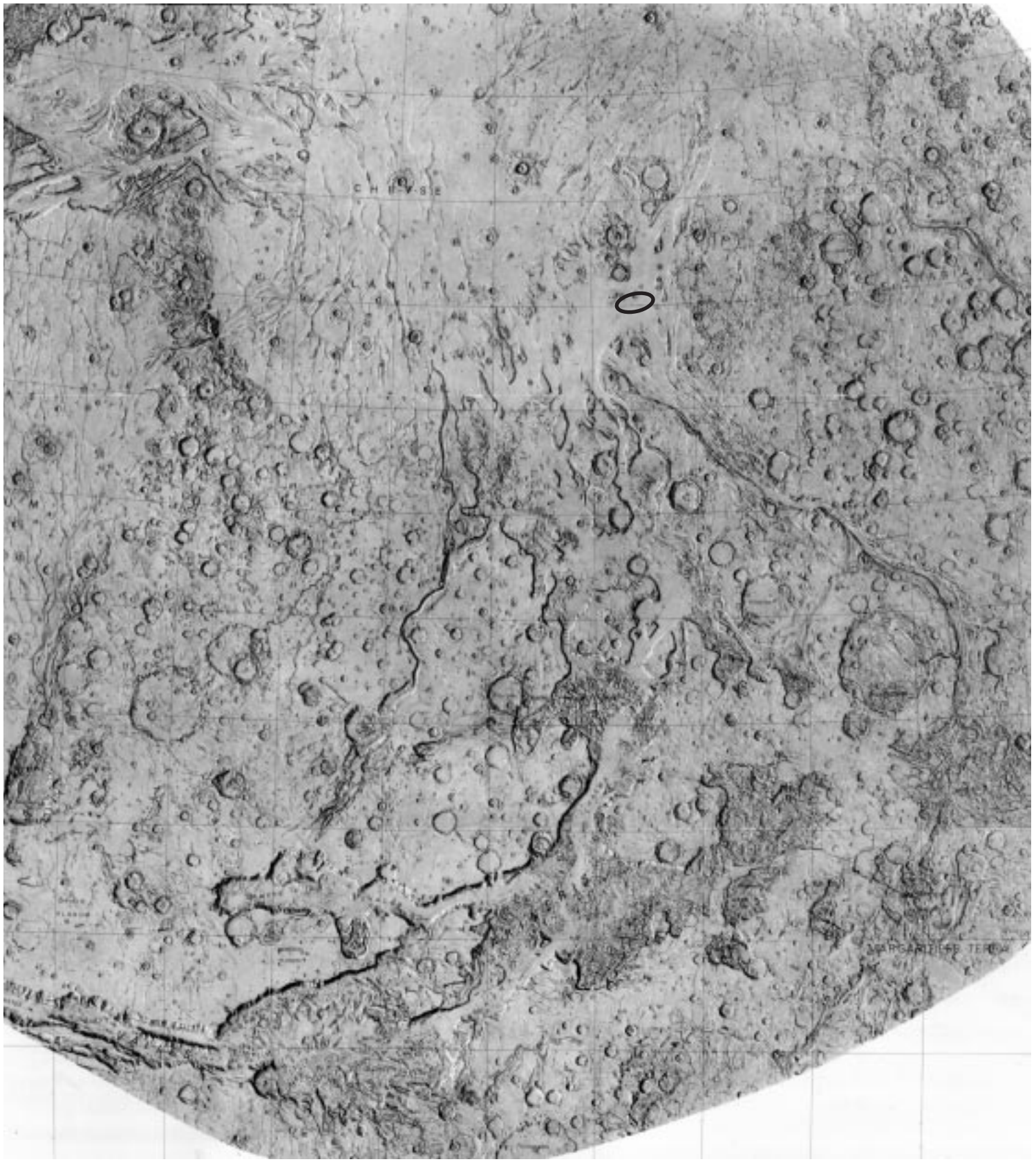
Scale: Ares Vallis is about 1,500 km long.

Image 15

- What information does this wide-area view add to your understanding of Image 12?
- How much water flowed in this region, a little or a lot?
- Do you see any sources for water?
- Why is the area at the end of the channel so smooth?

Image 16

- How big is this area?
- Is Ares Vallis the only place water flowed?
- Which direction is uphill?
- What is the general topography of this region?
- Where might the water that flowed in these channels have come from?
- Describe the distribution of craters in this region.
- What might explain this pattern of distribution?
- What are some differences between the craters on the plain and in the highlands?
- What might explain the differences between the craters in these two areas?
- What do you think the Chryse Planitia looked like when water flowed in the channels?


1000 km